Validation of the Canadian clinical practice guidelines for nutrition support in mechanically ventilated, critically ill adult patients: Results of a prospective observational study*

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Objective: **Recently, evidence-based clinical practice guidelines for the provision of nutrition support in the critical care setting have been developed. To validate these guidelines, we hypothesized that intensive care units whose practice, on average, was more consistent with the guidelines would have greater success in providing enteral nutrition.**

Design: **Prospective observational study.**

Setting: **Fifty-nine intensive care units across Canada.**

Patients: **Consecutive cohort of mechanically ventilated patients.**

Interventions: **In May 2003, participating intensive care units recorded nutrition support practices on a consecutive cohort of mechanically ventilated patients who stayed for a minimum of 72 hrs. Sites enrolled an average of 10.8 (range, 4–18) patients for a total of 638. Patients were observed for an average of 10.7 days.**

Measurements and Main Results: **We examined the association between five recommendations from the clinical practice guidelines most directly related to the provision of nutrition support (use of parenteral nutrition, feeding protocol, early enteral nutrition, small bowel feedings, and motility agents) and adequacy of enteral nutrition. We defined adequacy of enteral nutrition as the percent of prescribed calories that patients actually received. Across sites, the average adequacy of enteral nutrition over the observed stay in intensive care unit ranged from 1.8% to 76.6% (average 43.0%). Intensive care units with a greater than median utilization of parenteral nutrition (>17.5% patient days) had a much lower adequacy of enteral nutrition (32.9 vs. 52.7%, $p < .0001$). Intensive care units that used a feeding protocol tended to have a higher adequacy of enteral nutrition than those that did not (44.9 vs. 38.5%, $p = .03$). Intensive care units that initiated enteral nutrition on >50% of their patients within the first 48 hrs had a higher adequacy of enteral nutrition than those that did not (48.1 vs. 34.4%, $p < .0001$). Intensive care units that had a >50% utilization of motility agents and/or any small bowel feedings in patients with high gastric residuals tended to have a higher adequacy of enteral nutrition than those intensive care units that did not (45.6 vs. 39.2%, $p = .04$, and 48.4 vs. 41.8%, $p = .16$, respectively).**

Conclusions: **Intensive care units that were more consistent with the Canadian clinical practice guidelines were more likely to successfully feed patients via enteral nutrition. Adoption of the Canadian clinical practice guidelines should lead to improved nutrition support practice in intensive care units. This may translate into better outcomes for critically ill patients receiving nutrition support. (Crit Care Med 2004; 32:2260–2266)**

KEY WORDS: nutrition support; enteral nutrition; parenteral nutrition; survey; practice guidelines; quality improvement

Nutrition support is considered an integral component of standard supportive care in the critically ill patient. The benefits of nutrition support in general include improved wound healing, a decreased catabolic response to injury, enhanced immune system function, improved gastrointestinal structure and function, and improved clinical outcomes including a reduction in complication rates and length of stay with accompanying cost savings (1). Given the consistent number of experimental and clinical studies documenting better outcomes associated with enteral nutrition (EN), EN is preferentially recommended over parenteral nutrition (PN) when nutrition support is being considered for critically ill patients (1, 2).

However, providing nutrients and nutrition support is not without adverse effects or risks. Acquired infection, particularly ventilator-associated pneumonia, is a major problem for critically ill patients, resulting in increased morbidity, mortality, and health care costs (3–5). The use of high-volume intragastric feeding, particularly in supine patients, may increase the risk of ventilator-associated pneumonia via a mechanism of gastroesophageal regurgitation and pulmonary microaspiration (6, 7). Parenteral nutrition has been associated with gut mucosal atrophy, overfeeding, hyperglycemia, adverse effects on immune function, an increased risk of infectious complications, and increased mortality in critically ill patients (8). Although providing supplemental glutamine to critically ill patients may increase their chances of survival (9), providing arginine to the same patients may increase their mortality rate (10).

Thus, nutrition support must be viewed as a double-edged sword, and strategies that maximize the benefits of nutrition support while minimizing the

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associated risks need to be considered in formulating clinical recommendations. Working with a multidisciplinary group of practitioners in Canada, we recently developed practical, evidence-based clinical recommendations for the provision of nutrition support to the mechanically ventilated, critically ill, adult patient (11). Whereas previous guidelines (12, 13) relied heavily on expert opinion as to the relative merits of various nutrition interventions, we conducted current systematic reviews and meta-analyses of randomized trials to establish the evidentiary basis of our guidelines. We systematically reviewed >30 nutrition support topics relevant to intensive care unit (ICU) patients and summarized the evidence. Consistent with how biomedical guidelines are developed, in a transparent fashion, our committee then weighed the evidence (validity, precision, and homogeneity) and considered safety, feasibility, and cost in order to generate the guideline statements. Seventeen specific recommendations were developed, whereas data were considered insufficient or too conflicting to be able to put forward recommendations on 15 additional topics (Table 1; see www.criticalcarenutrition.com for current summaries and clinical practice guidelines [CPGs]). When subject to critical appraisal, the CPGs meet or exceed international standards for guideline development and presentation (14). However, it is unknown whether their use will lead to improvements in nutrition support practice or in patient outcomes.

To further validate these ICU nutrition support guidelines, we hypothesized that ICUs whose practice, on average, was more consistent with the guidelines would have greater success with EN. Before their widespread dissemination, we conducted a survey of nutrition support practices across Canada to test this hypothesis.

METHODS

We conducted a prospective, observational cohort study of Canadian ICUs affiliated with a registered dietitian. We contacted 86 eligible ICUs; 59 agreed to participate (response rate 68%). Study materials, including an implementation manual with explicit instructions on how to record study data, were mailed to participating sites. Dietitians were instructed to provide their nutritional prescription for total goal calories and protein from day 1 of admission, even if the patient was not initiated on nutrition support until later. This prescription served as the denominator in later evaluations of adequacy of nutrition support. We did not standardize the approach to deriving the nutritional prescription in this observational study. Dietitians calculated goal calories and protein based on their local standards of practice.

Data Collection. We asked the dietitians to complete a form describing the characteristics of their hospital and ICU and general aspects of nutrition support practice (use of feeding protocols or algorithms, etc.). Then on May 7, 2003, we conducted a point prevalence survey of actual practice. All ICU patients who had been in ICU for >72 hrs and had been mechanically ventilated for ≥48 hrs were included in this study. Sites were instructed to continue adding consecutive patients to their cohort until they had a minimum of ten pa-

Table 1. Summary of topics and recommendations

1.	EN vs. PN	Does EN compared with PN result in better outcomes in the critically ill adult patient?	Based on one level 1 study and 12 level 2 studies, when considering nutrition support for critically ill patients, we **strongly recommend** the use of EN over PN.
2.	Early vs. delayed nutrient intake	Does early EN compared with late EN result in better outcomes in the critically ill adult patient?	Based on eight level 2 studies, we **recommend** early EN (within 24–48 hrs following admission to ICU) in critically ill patients.
3.	Strategies to optimize delivery and minimize risks of EN: Feeding protocols	Does the use of a feeding protocol result in better outcomes in the critically ill adult patient?	There are **insufficient data** from randomized trials to recommend the use of a feeding protocol in critically ill patients. If a feeding protocol is to be used, based on one level 2 study, a protocol that incorporates prokinetics (metaclopramide) at initiation and tolerates a higher gastric residual volume (250 mL) **should be considered** as a strategy to optimize delivery of EN in critically ill adult patients.
4.	Strategies to optimize delivery and minimize risks of EN: Motility agents	Compared with standard practice (placebo), does the routine use of motility agents result in better clinical outcomes in the critically ill adult patient?	Based on a systematic review, in critically ill patients who experience feed intolerance (high gastric residuals, emesis), the use of metoclopramide as a motility agent **should be considered**.
5.	Strategies to optimize delivery and minimize risks of EN: Small bowel feeding	Does enteral feeding via the small bowel compared with gastric feeding result in better outcomes in the critically ill adult patient?	Based on 11 level 2 studies, small bowel feeding compared with gastric feeding may be associated with a reduction in pneumonia in critically ill patients. In units where obtaining small bowel access is feasible, we **recommend** the routine use of small bowel feedings. In units where obtaining access involves more logistical difficulties, small bowel feedings **should be considered** for patients at high risk for intolerance to EN (on inotropes, continuous infusion of sedatives, or paralytic agents, or patients with high nasogastric drainage) or at high risk for regurgitation and aspiration (nursed in supine position). Finally, in units where obtaining small bowel access is not feasible (no access to fluoroscopy or endoscopy and blind techniques not reliable), small bowel feedings **should be considered** for those select patients who repeatedly demonstrate high gastric residual volumes and are not tolerating adequate amounts of EN delivered into the stomach.

EN, enteral nutrition; PN, parenteral nutrition; ICU, intensive care unit.

This table highlights five of the clinical recommendations discussed in this manuscript. For a complete version of the Canadian Clinical Practice Guidelines, see our Web site: www.criticalcarenutrition.com

tients per site. From the charts of included patients, we recorded use of nutritional support, motility agents, and small bowel feeding tubes from time of admission to ICU for a maximum of 12 days. The accuracy of data abstraction compared with source records was not assessed, but all data collection sheets were screened for logic, completeness, and consistency before being entered into the database.

Completed case report forms were either entered directly into a Web-based data collection tool (see www.criticalcarenutrition.com) or mailed to the Clinical Evaluation Research Unit at the Kingston General Hospital. All study forms were checked by the principal investigators to identify errors, inconsistencies, and omissions. Source documents were used to validate data that were directly entered over the Web. Data queries were sent back to study dietitians as necessary. To ensure accuracy, a second investigator verified data that were entered into a database.

Research ethics approval was obtained from Queen's University in Kingston, Ontario, and some additional centers if required for their participation. The majority of research ethics boards waived the need for informed consent for patient data.

Canadian Clinical Practice Guidelines. Of the 17 recommendations generated, *a priori*, we selected the five that were most directly related to the optimal provision of enteral nutrition (use of EN and PN, feeding protocol, early EN, small bowel feedings, and motility agents) and herein describe the association of compliance with these recommendations and adequacy of EN. *A priori*, we hypothesized that ICUs whose practice, on average, was more consistent with the guidelines would have greater success in providing EN.

Statistical Analysis. Patient- and site-level characteristics were described using means or medians with ranges for continuous variables and counts with percentages for categorical variables. Given the preferential recommendation for EN over PN, we defined success with nutritional support as adequacy of EN. This was calculated as the amount of calories received by EN divided by the amount that should have been received (prescribed) as per the dietitian's assessment. Forty study patients did not receive nutrition support or have a prescription recorded and were excluded from the analysis of adequacy of nutrition support. To aggregate sites as more or less consistent with the guideline recommendations, we examined the pattern of utilization and divided sites into two groups based on the median or other convenient groupings. The groupings were defined before examining the adequacy of EN.

The average adequacy of EN was compared across patient-level characteristics as well as site-level characteristics. Patient-level comparisons are based on the patient averages as calculated over all observed study days. Site-level comparisons are based on the patient averages aggregated within each site. The reported p values were estimated by a three-level hierarchical linear model (15) that accounted for the within-site and within-patient correlation (16). This model fit an overall quadratic trend of the adequacy of EN over the 12 study days and then added a fixed effect to test the contrast of interest. The quadratic model was the lowest order polynomial that adequately fit the average adequacy of EN over the 12-day study period. All analysis was conducted in SAS version 8.2 (17).

RESULTS

Characteristics describing the 59 participating ICUs and the corresponding 638 patients are found in Tables 2 and 3, respectively. The sites enrolled an average of 10.8 (range, 4–18) patients, and patients were observed for an average of 10.7 days (range, 3–12). Only 598 (94%) study subjects had a nutrition prescription recorded and were included in the subsequent analyses.

Adequacy of EN. At the patient level, on average, 44.6% of calories were received by EN (range, 0.0–117.3%). When the adequacy of EN in each patient was aggregated across sites, the average adequacy of EN over the observed stay in ICU ranged from 1.8% to 76.6% (average 43.0%).

Use of Nutrition Support. The CPGs recommend the use of EN preferentially to the use of PN, and the routine use of PN for patients with an intact gastrointestinal tract is discouraged. All of the study subjects with a prescription received some nutritional support (EN or PN); 436 (72.9%) received enteral nutrition only, 64 (10.7%) received parenteral nutrition only, and 98 (16.4 %) received both. The adequacy of EN was greater for patients who received only EN (57.1%) compared with patients who received both EN and PN (18.0%, $p < .0001$). At an ICU site level, the percentage median number (range) of patient days of observation receiving EN, PN, and both was 64.1% (8.3–87.5), 17.5% (0–55.0), and 2.4% (0–11.1) respectively.

Since the median PN utilization was 17.5% patient days, we divided ICUs based on the median utilization of PN. For those sites that used more than the median utilization of PN (>17.5 patients days), the adequacy of EN was significantly less than those sites that used <17.5% patient days (32.9 vs. 52.7, $p < .0001$).

Use of Feeding Protocol. The CPGs concluded that there were insufficient data from randomized trials to recommend the use of a feeding protocol in critically ill patients. Nonrandomized studies suggest that a feeding protocol can improve the delivery of EN to critically ill patients. If a feeding protocol was to be used, based on one level 2 study, a protocol that incorporates prokinetics (metoclopramide) at initiation and tolerates a higher gastric residual volume (250 mL) should be considered as a strategy to optimize delivery of enteral nutrition in critically ill adult patients.

Of the 59 sites participating in the survey, 41 (69.5%) reported that they used some form of a feeding protocol or algorithm and 18 (30.5%) did not. Those ICUs that used such a protocol had a higher adequacy of EN than ICUs that did not use protocols (44.9 vs. 38.5%, $p = .03$).

Timing of Nutrition Support. The CPGs recommend early enteral nutrition (within 24–48 hrs following admission to ICU) in critically ill patients requiring nutrition support. For those patients who received enteral nutrition within the 12 days of observation (n = 534), the median time from admission to start of EN was 1.6 days (range, 0.00–10.5 days). For the 340 (63.6%) patients who had EN initiated within 48 hrs, the overall adequacy was greater than for those patients who did not receive EN within 48 hrs (59.8 vs. 24.5%, $p < .0001$). At a site level, we aggregated sites based on >50% or <50% of their patients receiving EN within the first 48 hrs. The 37 (62.7%) ICUs that initiated EN on >50% of their patients within the first 48 hrs had a higher adequacy of EN than those that had fewer patients with early EN initiation (48.1 vs. 34.4%, $p < .0001$).

Strategies to Maximize the Delivery of EN. The CPGs recommend the use of motility agents (metoclopramide) and small bowel feedings as a strategy to maximize the delivery of EN, particularly in patients experiencing problems tolerating their EN (i.e., high gastric residual volumes). Of the 534 patients who received enteral nutrition, 159 (29.8%) experienced high gastric residuals. Of these, 122 (76.7%) received motility agents; metoclopramide, domperidone, and erythromycin were used on 78.6%, 18.3%, and 3.1% of the patient days on motility agents, respectively. Of the 159 patients who experienced high gastric residual volumes, 26 (16.4%) received small bowel feedings at some point in their ICU course. There was no difference in adequacy comparing patients who experienced high gastric residuals and were

Table 2. Characteristics of participating intensive care units (ICUs, n = 59)

Academic	34 (58)
Community	25 (42)
Size of hospital, beds, mean (range)	417 (97–1,130)
Type of ICU	
Open	10 (17)
Closed	46 (78)
Other	3 (5)
Case mix[a]	
Medical	54 (92)
Surgical	57 (97)
Trauma	30 (51)
Neurological	35 (59)
Neurosurgical	17 (29)
Cardiac surgery	9 (15)
Burns	12 (20)
Pediatrics	21 (36)
Other	50 (85)
Presence of ICU director	57 (97)
Size of ICU, beds, mean (range)	16 (7–36)

Values are given as n (%) unless noted otherwise.

[a]Percentages do not add to 100% because centers have more than one case mix.

Table 3. Demographics of study patients

Characteristic	All Study Patients n = 638
Mean age, yrs (range)	62 (15–94)
Male, n (%)	388 (61)
Female, n (%)	250 (39)
Admission diagnosis, n (%)	
Elective surgery	94 (15)
Emergency surgery	143 (22)
Medical	332 (52)
Trauma	60 (9)
Burns	9 (1)
Body mass index, mean (range)	27.2 (10.5–64.9)
28-day mortality, n (%)	130 (20.4)
ICU length of stay, days, median (interquartile range)	14.8 (8.1–31.0)

prescribed motility agents with those who were not prescribed motility agents (43.9 vs. 41.1%, $p = .61$). Similarly, patients who experienced high gastric residuals and were given small bowel feeding at some point did not differ significantly from patients who did not receive small bowel feedings (49.9 vs. 42.0%, $p = .32$). Fifty-three of the 59 ICUs had at least one patient with high gastric residuals. From these ICUs, the proportion of patients with high gastric residuals who received motility agents and small bowel feedings was an average of 60.9% (range, 0–100) and 7.1% (range, 0–100), respectively.

ICUs that used motility agents in >50% of their patients with high gastric residuals had a higher adequacy of EN that those ICUs with a lower utilization of motility agents (45.6 vs. 39.2%, $p = .04$). ICUs that used small bowel feedings in any of their patients with high gastric residuals tended to have a higher adequacy of EN that those ICUs that did not, although the difference was not statistically significant (48.4% vs. 41.8%, $p = .16$).

DISCUSSION

Several studies document considerable variation in nutrition support practice in ICUs (18–21). Recent efforts to standardize the approach to nutrition support and provide systematic care to complex patient populations have been shown to decrease practice variation, improve a variety of clinical outcomes, and at the same time result in significant cost savings (22, 23), Given such observations, we question whether care is optimally applied in ICUs around the world. Many practitioners believe that evidence-based practice guidelines are the best tool to move from opinion-based medicine (where one observes tremendous variation in practice) to evidence-based practice (where one observes less variation and care more consistent with "best practice") (24). Accordingly, consistent with international standards of guideline development, we produced evidence-based CPGs as a strategy to improve delivery of nutrition in ICUs across Canada. However, it is unknown if patients will do better if the Canadian CPGs (11) are adopted. Before their widespread dissemination, in an attempt to validate them, we conducted an observational study and examined the association between recommendations most directly related to the optimal provision of nutrition support and adequacy of EN across all patients and sites. These guidelines were designed to apply to the average ICU patient; thus, by design, we evaluated them in a heterogeneous ICU patient population.

We observed considerable variation in performance with respect to nutrition support practice and in that those ICUs that were more consistent with the guidelines had greater success with providing EN. The adequacy of EN was greater for patients who received only EN compared with patients who received both EN and PN. For ICUs that used more than the median utilization of PN, the adequacy of EN was significantly less than those sites that used less PN. The ICUs that used such a protocol had a higher adequacy of EN than ICUs that did not use these protocols. For those patients who had EN initiated within 48 hrs, their overall adequacy was greater than for those patients who received EN after 48 hrs. ICUs that had a >50% utilization of motility agents and/or any small bowel feedings in patients with high gastric residuals tended to have a higher adequacy of EN than those ICUs that did not. It was not the intent of this study to explain why the variation in performance existed; rather, we focused on describing the association between better performing sites and our clinical practice guidelines. Differing levels of training, interest, or amount of dietitian support or differences in patient characteristics may account for some of the differences observed. Exploring differences across sites, regardless of patient characteristics, can illuminate significant associations that can lead to improvement in patient outcomes, as illustrated by other recent observational studies (25–27).

The weakness of our observation study design is a major limitation of this study. Clearly, a randomized trial would have provided stronger inferences about the merits of these guidelines. However, in the absence of such a randomized study, data from our observational study are better than no data at all to judge the relative merits of this guideline. Although we demonstrated significant differences in nutrition practice performance across sites, a further limitation of this study was that we did not measure patient outcomes. The small differences in nutrition support practices may not translate into differences in clinically important end points.

Whether patients in the ICUs that were more consistent fared better than those in ICUs that were less consistent is unknown. However, recent evidence from another Canadian study would suggest that there is an association with improving nutrition support practice and improved clinical outcomes. In a multiple-center, cluster randomized clinical trial of nutrition algorithms for critical care enteral and parenteral therapy (ACCEPT), Martin and colleagues (28) tested different dissemination strategies for novel nutrition algorithms that tended to promote the early use of EN. Sites were randomized to active or passive dissemination strategies. Over the duration of ICU stay, patients in the intervention arm received

significantly more days of enteral nutrition (70% vs. 53% patient-days, $p = .02$) and there was a trend toward earlier institution of enteral nutrition (1.53 vs. 2.34 days, $p = .07$). In this study, these improvements in nutrition support practice were associated with a significant improvement in clinical outcomes. In the intervention arm, the overall mortality rate at hospital discharge (24% vs. 37%, $p = .02$) and the average length of hospital stay (25 vs. 34 days, $p = .002$) were both significantly reduced compared with patients in the control group. Based on the results of the ACCEPT study (28), improving nutrition support practices may translate into better outcomes for critically ill patients receiving nutrition support.

In contrast, data from an observational study suggest that providing close to 100% of goal calories is associated with worse clinical outcomes (29). In this study, on average, patients received about 50% of their goal calories and then investigators divided the cohort of 187 patients into three groups: those who received 0–32% of recommended calories, those who received 33–65% of goal calories, and those who received >66% of goal calories. Compared with the group who received the least calories, those who received the most calories were much less likely to be discharged alive from hospital (odds ratio, 0.82; 95% confidence intervals, 0.70–0.94) and the middle group was much more likely to leave hospital alive (odds ratio, 1.22; 95% confidence intervals, 1.15–1.29). Whether patients who receive >66% of goal calories are experiencing harm related to the provision of calories, the use of parenteral nutrition, or some other nonnutritional mechanisms remains to be elucidated. In our study, sites that were more compliant with the guidelines still only averaged 45–55% of goal calories, as compared with 35–45% in the less compliant ICUs. Thus our findings are consistent in that maximizing the delivery of EN up to a certain level is associated with clinical benefits. How many calories to provide is an important research question that needs to be answered by further studies.

Simply developing the Canadian guidelines and publishing them in peer-reviewed literature may be insufficient, as there is an increasing recognition of the failure to translate research findings into practice. To achieve real, meaningful, sustained change in practice, the production of evidence-based clinical practice guidelines needs to be combined with an aggressive strategy to disseminate and implement the guidelines. In general, passive approaches such as peer-reviewed publications and didactic seminars/lectures are generally ineffective and unlikely to result in behavior change (30, 31).

Promising approaches include educational outreach programs (32–39) (a trained person meets with providers in their practice setting to provide information with the intent of changing the providers' performance), educational materials (40) (distribution of published recommendations for clinical care including practice guidelines, audiovisual materials, pocket cards, electronic mail, posters, manuals etc.), conferences (41) (seminars, interactive workshops), audit and feedback (39) (a summary of clinical performance over a specified period of time highlighting areas of strength and weakness), advanced organizers (materials given to participants attending a workshop ahead of time to facilitate their learning process), listserv (an electronic method for participants to ask and respond to questions among themselves), and reminders (regular communication via electronic mail, teleconference) (40). Multifaceted interventions (any intervention that includes two or more of these) targeting different barriers to change are more likely to be effective than single interventions (31, 34, 35, 42, 43).

CONCLUSION

One of the most consistent findings in health services research is the gap between evidence and practice (44). Approximately 30–40% of patients do not receive care according to present scientific evidence, and about 20–25% of care provided is not needed or is potentially harmful (45, 46). In an attempt to improve the practice of nutrition support in ICUs, to minimize the risks and maximize the benefits of nutrition therapy, we have developed evidence-based CPGs. In this prospective study, we have shown that ICUs that are more consistent with these guidelines are likely to provide more EN than those that are not as consistent. We plan to actively disseminate these CPGs using a Web-based (47), multifaceted strategy that includes an interactive workshop. The multifaceted strategy includes the use of posters, pocket cards, manuals, advance organizers, site reports, list servs, and regular communication via teleconference and email. We expect that adoption of these CPGs will lead to improved nutrition support practice in ICUs around the world. This may translate into better outcomes for critically ill patients receiving nutrition support.

Adoption of the Canadian clinical practice guidelines should lead to improved nutrition support practice in intensive care units. This may translate into better outcomes for critically ill patients receiving nutrition support.

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Society of Critical Care Medicine
VISION STATEMENT

SCCM envisions a health system in which
all critically ill and injured persons will obtain care
that promotes desired outcomes for individuals and society,
is consistent with emerging knowledge,
and occurs in a humane and respectful manner.

Adopted by the SCCM Council
September 28, 1997